

Thin Glass Sheets as Disposable Debris Shields on NIF

On the National Ignition Facility (NIF), considerable amount of debris will be generated when the 192 laser beams irradiate the inertial confinement fusion (ICF) and other experimental targets. The debris consists of various-sized particles ranging from atomic vapor to ~millimeter-sized shrapnel. Small-sized debris can coat the debris shield while larger-sized shrapnel can produce pits in the debris shield. Both mechanisms lead to increased optical damage of the debris shield on subsequent laser shots and consequently shorten its service life. This could significantly increase the operating cost of NIF. One approach to resolve this issue consists of protecting each main debris shield on NIF using a thin glass sheet as a disposable debris shield (DDS). Such sheets would have to be changed on each laser shot. For this method to be practical, the glass sheets would have to be inexpensive and have acceptable wavefront and transmission characteristics.

We have recently identified a thin glass sheet material for this application. The glass sheets can be manufactured with thickness as thin as 50 μm with good optical quality. They were developed originally for use as screens on flat-panel displays. Figure 1 shows one of such thin sheets produced by Corning.

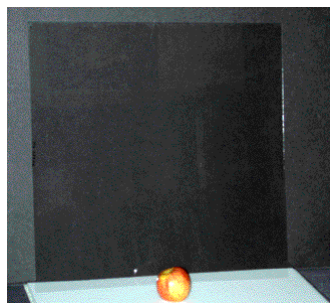


Figure 1. A 440x440-mm-size, 0.7-mm-thick glass sheet.

We have acquired such sheets from several vendors for evaluation purposes. The glass sheets are made either through extrusion, fusion bonding, or a float process. Generally, the extrusion-drawn glass sheets tend to exhibit large thickness variations orthogonal to the draw direction and very small variations along the draw direction. The measured wavefront of one such sheet, shown in Figure 2, illustrates this point.

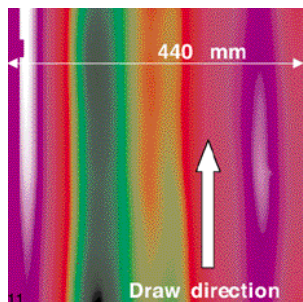


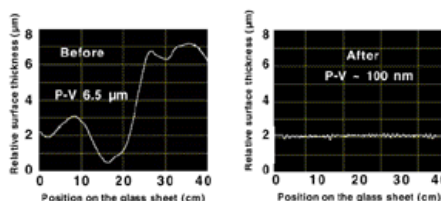
Figure 2. Phase map of a 0.7-mm-thick glass sheet. Peak-to-valley surface thickness variation is about 8.5 μm .

Float glass sheets tend to have more two-dimensional thickness variation. When such thin sheets are used as DDS, the focal spot on NIF is degraded due to the additional phase aberrations of the thin glass sheets. We are currently evaluating the feasibility of using such sheets on NIF.

We successfully developed a wet etch tool to improve the flatness of thin glass sheets for NIF and for the Eyeglass project. An example of the improvement of the wavefront after the processing is shown in the graphs below. Numerical simulations suggest that the removal of the one-dimensional thickness variations is quite adequate for ICF spot sizes. Another way to accommodate the DDS aberrations is by "tightening" the continuous phase plate spot to allow for its enlargement due to DDS aberrations.

The acceptability of this DDS concept is currently under evaluation from the target physics perspective. In parallel, we are also assessing the survivability of these debris shields under the shrapnel impact as well as their response to high-power NIF pulse irradiation.

Peak-to-Valley (P-V) Wavefront



(S. Dixit & P. Whitman)



1100-nm Yb:Fiber Laser Delivered to the Air Force Research Lab

Under sponsorship of the Air Force Research Laboratory (AFRL), we have designed, built, and tested a Yb:fiber laser that produces single-line and single-mode 2-W output power at 1100 nm. This very bright source will be fed to a more powerful amplifier at the AFRL, located at Kirtland Air Force base. Capt. Nathan Brilliant completed this work at Lawrence Livermore National Laboratory in conjunction with colleagues from Laser Science & Technology.

The oscillator is a standard 1100-nm fiber laser manufactured by Ionas of Denmark, which we spliced to a fiber isolator and wavelength division multiplexer to seed a preamplifier. The output power of the preamplifier is 43 mW with a slope efficiency of 33%. The output from the preamplifier is again spliced to a fiber-coupler, collimated through a "free space" isolator and then propagated to seed to a double-clad amplifier. The double-clad fiber, made by Polaroid, is 10 meters long with an 8- μm -diameter doped core and 165- μm hexagonal pump cladding. The seed and pump beams are counterpropagated in the amplifier to prevent early saturation. A fiber-coupled diode laser was used to pump the double-clad fiber amplifier. Since the pump beam is trapped in the pump cladding, it crosses the ytterbium-doped core many times and is absorbed along the 10-meter length. We successfully achieved an optical-to-optical efficiency of 28%.

Although this laser does not operate at the wavelength commonly used in telecommunications, it can be fabricated using fiber-optic components developed for optical communication. We are exploring other possible applications, including laser guide stars, for this single-mode fiber laser.

(Capt. N. Brilliant & A. Drobshoff)